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A sero-epidemiologic study of a water-borne epidemic of viral hepatitis in Kolhapur City, India

By M. A. SREENIVASAN, A. SEHGAL, S. R. PRASAD* and S. DHORJE

National Institute of Virology (Indian Council of Medical Research), 20-A Dr Ambedkar Road, Post Box 11, *Pune* 411 001, *India*

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SUMMARY

Between February and March 1981 an epidemic of hepatitis occurred in Kolhapur City, Maharashtra State, India. Approximately 1200 cases of jaundice were reported; more than 300 patients were hospitalized and three died. The epidemiological investigations showed a distinct concentration of cases in municipal ward E of the city. Investigations of the ward E water supply system disclosed gross contamination of raw water with sewage at source. The serological studies revealed that the aetiological agent responsible for this epidemic was neither hepatitis A virus nor hepatitis B virus but was likely to have been due to a non-A, non-B hepatitis virus.

INTRODUCTION

An epidemic of hepatitis involving approximately 1200 persons occurred in Kolhapur City, Maharashtra State, India, between early February and late March 1981. The illness was characterized by the onset of low-grade fever, anorexia and nausea followed by symptoms of jaundice. No less than 300 patients were hospitalized and of these three died. The causative agent of this epidemic was attributed to non-A, non-B (NANB) hepatitis virus with faeco-oral mode of transmission. The epidemiologic investigation incriminated the municipal water supply as the vehicle of infection. This was confirmed by the inspection of waterworks and analysis of coliform counts prior to and during the epidemic. This paper describes the sero-epidemiologic findings.

Kolhapur City is situated in southern Maharashtra State 360 km south-west of Pune on the eastern bank of the Panchaganga river (Fig. 1). The population of the city at the time of the 1981 census was 340,306. A fraction of the population is mobile and moves outside city limits to the places of work. The city is divided into five wards under the Municipal Corporation, namely A, B, C, D and E. The C ward is smallest in area and located in the centre of the city. E ward is the largest and covers about one-half of the total area of the city. The residential areas in the city limits can be roughly classified into three categories. First there are independent bungalow-type houses which are located in areas of the city where people of higher

* Present address: Postgraduate Institute of Medical Education and Research, Department of Virology, Chandigarh 160 012, India.

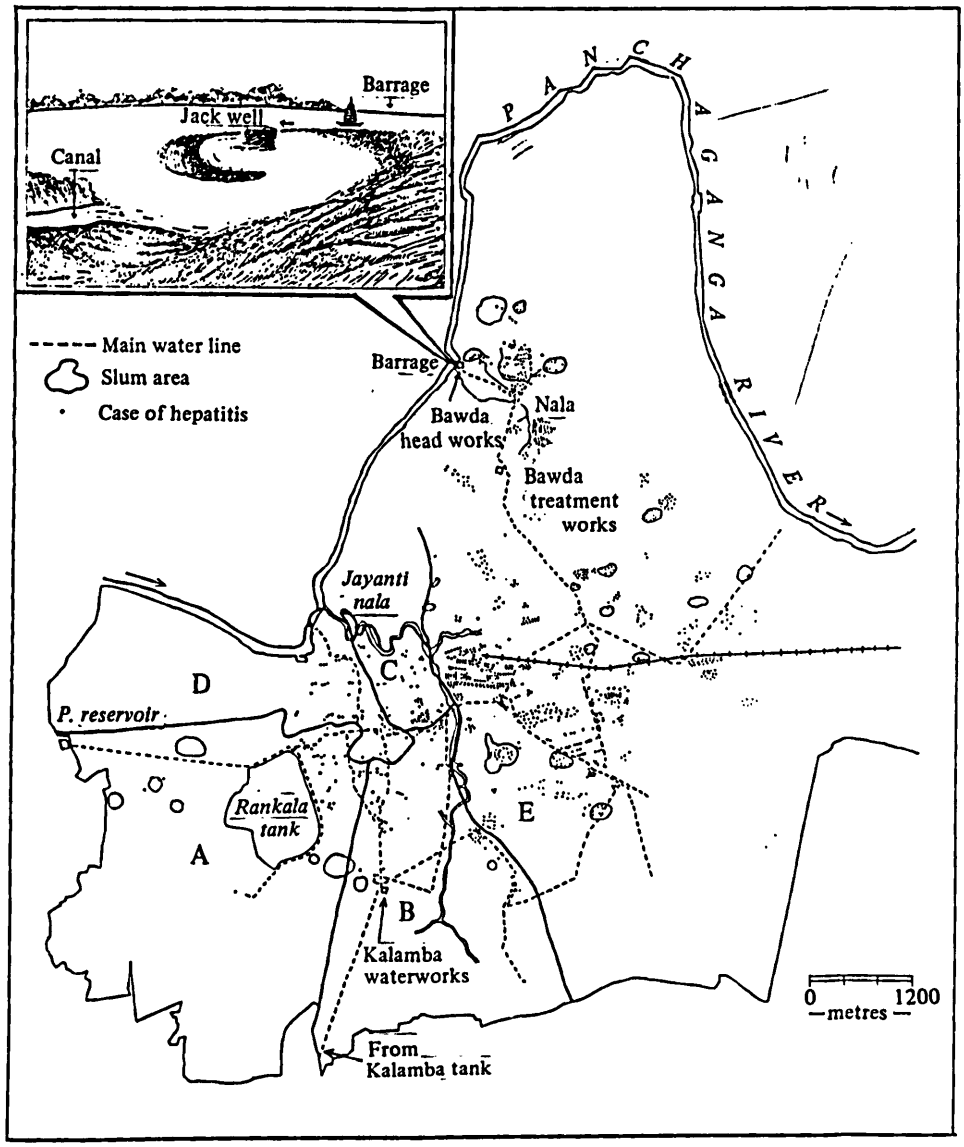

Fig. 1. Distribution of hepatitis cases in Kolhapur City.

socio-economic status reside. The bungalows are provided with underground piped drainage or a septic tank. Each bungalow has its own municipal tapwater connection. Secondly there are localities with small houses built in a row, side by side or back to back in small lanes. Here drainage is of the open type. The water and toilet facilities are shared by many families. Thirdly there are slums which are scattered within the city limits and have the highest population density. Families live in small huts which are closely packed together. Drinking water and toilet facilities are shared.

There are three main sources of water supply to the city. These are the Kalamba lake, the Bhogavati river and the Panchaganga river. Kalamba lake water is

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supplied to a portion of B ward. The Bhogavati river water is supplied to wards A, C, D and the remaining part of B. The Panchaganga river water is drawn through a jack well located downstream north of the city and is supplied exclusively to E ward. In drier months between December and April, a limited supply of water flows in the river and the water level near the jack well goes down.

The sewage disposal is by two means, underground piped drainage or open sewage. The underground piped drainage covers about 60 % of the city in especially planned localities. The drainage water is collected at a treatment plant and the sullage is let out for irrigation. The excess drainage effluent which is not handled by the disposal plant is left to flow into an open drainage canal named Jayanti Nala. Raw sewage from the other residential areas flows into Jayanti Nala by gravity, and it eventually joins the Panchaganga river about 3 km upstream from the water works (Fig. 1).

MATERIALS AND METHODS

Epidemiologic methods

To evaluate the true extent of the disease, we reviewed the records of admission of 'infective hepatitis' cases to the three main hospitals, namely C.P.R. Hospital, the Infectious Disease Hospital and Mary Wanless Hospital from January 1978 to March 1981. In the meantime the health authorities of Kolhapur City had initiated a house-to-house survey from 9 March to 14 March 1981 to assess the magnitude of the problem. The questionnaire designed for this survey was used by about 60 health workers of the corporation. The respondents were asked about hepatitis illness, date of onset, medical treatment obtained and the illness of any family member. All the five wards were covered within that period. Subsequently we visited all the wards and confirmed the cases already reported in the survey.

Clinical studies

The cases of hepatitis admitted to the three hospitals as well as the cases recorded in the house-to-house survey were clinically examined by us and a case history sheet was prepared for each patient. The hospital records gave the details of laboratory investigations done in addition to the clinical features. Blood samples were collected from acute cases and stool samples were obtained during early acute phase of illness. Since the survey reported the maximum number of cases from E ward, we selected the A ward to serve as control, because comparatively few cases were recorded from this ward and the socio-economic profile closely resembled that of E ward. Approximately 40 days after the first visit convalescent-phase serum samples were collected from the patients. At the same time the patients were also examined clinically for recovery or residual effect.

Laboratory methods

The acute and convalescent-phase sera collected from hepatitis cases and the sera obtained from control group were tested as follows: (*a*) discontinuous counter immunoelectrophoresis (Wallis & Melnick, 1971) and enzyme-linked immunosorbent assay (ELISA) test kit (Organon, Holland) were employed for the detection of hepatitis B surface antigen (HBsAg) antigenaemia; (*b*) HAVAB-M

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Table 1. *Incidence of hepatitis during the epidemic period*

City wards	House-to-house survey				Hospital records*	
	Population	Cases	Attack rate/ 10000	Percentage of total	Cases	Percentage of total
A	64856	43	6·63	3·7	11	5·0
B	50841	61	12·0	5·2	15	6·8
C	39954	70	17·52	6·0	14	6·4
D	37862	25	6·60	2·1	9	4·1
E	146793	970	66·08	83·0	171	77·7
Total	340306	1169	34·35	100·0	220	100·0

* February and March 1981.

test kit (Abbott Laboratories, USA) was used to detect the presence of specific IgM class antibodies to hepatitis A virus (HAV); (*c*) HAVAB test kit (Abbott Laboratories, USA) was used for the detection of antibodies to HAV; (*d*) total IgM and IgG levels (mg/dl) were estimated in acute, convalescent and control serum samples by radial immunodiffusion test (Mancini, Carbonara & Heremans, 1965).

RESULTS

Epidemiological characteristics

Incidence

In all, 1169 cases of hepatitis were recorded in the house-to-house survey covering a total population of about 340,000. From this we can estimate an attack rate of 34·35 per 10,000 population with frank icterus. Two hundred and twenty cases were admitted to hospital between February and March 1981 (Table 1).

Geographical distribution

The geographical distribution of survey cases is shown in Fig. 1. Of the 1169 cases in survey, 970 cases were recorded from ward E, with an estimated attack rate of 66·08 per 10000. This closely matched the hospital admissions of 77·7 % of the cases from ward E. The attack rate was distinctly low in other wards, where it ranged from 6·6 per 10000 to 17·52 per 10000 (Table 1). In certain congested localities, series of cases were seen in the neighbourhood along the same street.

Hospital records

The records of admission of the three major hospitals from January 1978 to March 1981 showed an unusual increase in the number of admissions between February and March 1981, as compared with the corresponding periods of previous years. The weekly admissions of cases during February and March are presented in Fig. 2. The hospital records showed that sporadic cases of hepatitis admitted to these hospitals came not only from within Kolhapur City but also from the neighbouring towns and villages. On an average 239·6 sporadic cases of hepatitis are admitted annually to the three hospitals, with a monthly average of admissions ranging from 15·5 to 23·0 cases. However, the total admission of hepatitis cases from January to March 1981 was 305, with an average of 101·7 cases per month.

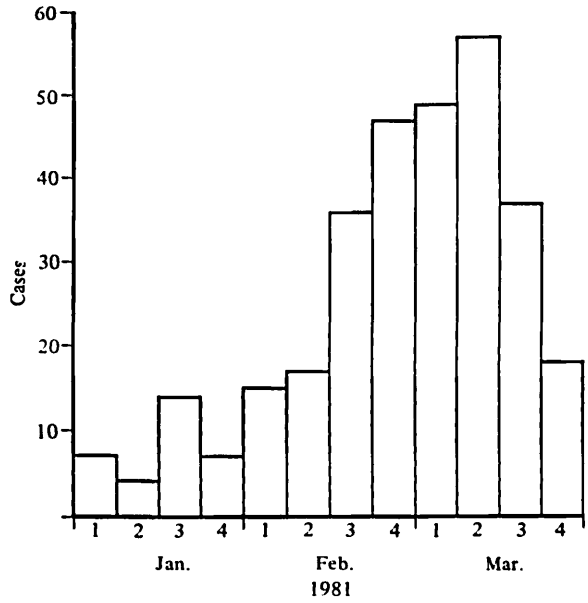

Fig. 2. Hepatitis cases by week of admission to hospital, January–March 1981.

Associations with sex and age

The survey as well as hospital admission records revealed that the overall incidence of hepatitis was relatively more in males, with a male to female ratio approximating 2:1. The age distribution of hospitalized and survey cases is shown in Table 2. Sixty per cent of the cases were in the age group 16 to 35 years, with only a few being recorded in the paediatric age group. The analysis of variance done separately by sex showed that the mean age did not vary significantly ($P > 0{\cdot}05$) over a number of years. When the data were pooled for the years 1978 to 1980 and were compared with those for the epidemic quarter of 1981, no significant difference in age distribution was found for either sex ($P > 0{\cdot}05$).

Other features

Fig. 3 describes the monthly pattern of hospitalized cases from 1978 to 1981. Hepatitis cases were admitted to the hospitals throughout the year. The sporadic cases did not show a regular seasonal pattern of distribution. During the year 1981 there was a gradual increase in the number of cases from February with a sharp increase in the admission during February and March.

In general more cases were recorded among economically poorer sections residing in the congested areas where the state of hygiene was unsatisfactory and water and toilet facilities were shared by several families.

The secondary case attack rate within the families was distinctly low. Only 12·4% reported secondary cases among the household members. In general single cases were reported even in large families comprising 15 to 20 individuals. The secondary cases, when present in the same family, appeared at an interval of about one month after the primary cases. Only 14 out of 144 patients (9·7%) gave a

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Table 2. *Hepatitis cases by age and sex*

Age group (years)	Hospital records: 1978 M	1978 F	1979 M	1979 F	1980 M	1980 F	Total M	Total F	Jan.–Mar. 1981 M	Jan.–Mar. 1981 F	Survey March 1981 M	Survey March 1981 F
1–5	12	6	10	7	19	10	41	23	6	1	24	21
6–10	3	9	7	5	15	5	25	19	6	5	47	29
11–15	4	3	7	5	7	6	18	14	13	11	89	56
16–20	9	6	23	16	21	11	53	33	28	20	138	66
21–25	30	15	37	13	26	8	93	36	38	15	161	78
26–30	31	11	32	10	19	13	82	34	35	17	102	59
31–35	12	2	26	9	11	5	49	16	28	16	80	32
36–40	12	6	18	7	12	3	42	16	11	6	48	18
41–45	9	5	15	5	9	3	33	13	10	3	33	13
46–50	6	2	4	1	7	2	17	5	4	3	17	10
51+	8	2	8	9	15	2	31	13	13	10	35	13
Total	136	67	187	87	161	68	484	222	192	107	774	395

M = male, F = female.

history of having previously suffered from jaundice. The mortality rate among hospitalized cases was 1·4%. Of the three fatal cases recorded one female was in the second trimester of pregnancy.

Investigation of water supply and sewage disposal

Since the geographic distribution of cases of hepatitis indicated the highest concentration in ward E we concentrated our attention on investigating the water supply and sewage disposal in this area. The water supply to ward E, as indicated earlier, is drawn from the Panchaganga river through a jack well and pumped to Bawda waterworks. After sedimentation, rapid sandbed filtration and chlorination, water is boosted into five pressure-head zones located in the southern part of E ward. From here water is supplied to other areas by gravity. The average quantity of chlorine mixed per day maintains a level of 1·0 p.p.m. During the epidermic period the chlorine levels had been stepped up to 2·0 p.p.m. In addition to the major open sewage canal (Jayanti Nala) another canal of raw sewage joined the Panchaganga river about 50 metres from the jack well (Fig. 1, inset). This canal drained sewage water from areas with a high incidence of hepatitis.

Clinical features

A total of 142 hepatitis cases were clinically examined. The majority of cases had an acute onset (79·5%) and developed jaundice within a week of the appearance of associated symptoms. The onset of illness was sudden, with a history of fever in 64·3% of the cases which was either continuous or of intermittent type. While some patients complained of fever alone (45·9%) others had fever associated with chills (54·1%). The other symptoms were lassitude (76·5%), anorexia (75·0%), nausea (62·1%), vomiting (37·9%), headache (47·7%) and upper abdominal distress (63·8%). A few patients complained of constipation (17·4%), non-specific pruritis

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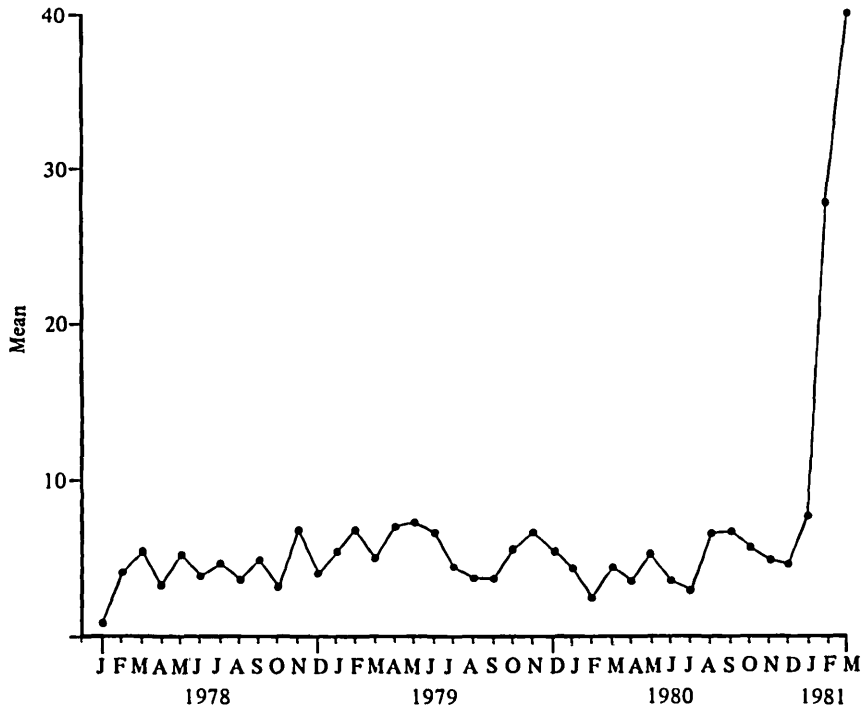

Fig. 3. Monthly admissions of hepatitis cases, 1978–1981.

(9·8 %), sore throat (10·6 %), cough (9·6 %) and diarrhoea (6·8 %). Signs of mild to moderate hepatomegaly were seen in 35·6 % of the cases.

Of the 142 hepatitis patients examined twelve females were pregnant. Among these one patient died 21 days after illness with signs of pedal oedema, premature delivery and hepatic coma. The acute-phase sera of this patient were positive for HBsAg.

The great majority of the patients had an uneventful recovery without complications. Only three patients complained of persistent jaundice.

Serological studies

Serum samples were collected from 279 cases of hepatitis at various intervals after the onset of illness. Of these, paired acute and convalescent-phase sera were collected from 129 patients with an interval of 40 days between the samples. Single acute-phase samples were collected from 150 cases. Both hospitalized and household cases were sampled but there were fewer of the latter than the former. In addition, sera were collected from 62 healthy individuals of ward A to serve as controls.

The results of serological studies are summarized in Table 3. Thirty-six cases (12·9 %) were HBsAg positive, while only one out of 62 (1·6 %) controls was positive. Out of the 36 HBsAg-positive patients 28 (77·8 %) were hospitalized cases.

A total of 136 cases of hepatitis were screened for the presence of specific IgM class antibody to HAV in their sera. Of these, 133 were negative for anti-HAV-IgM.

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Table 3. *Results of serological tests for HAV and HBV infection*

Age group (years)	Hepatitis cases			Control	
	Anti-HAV IgM	Anti-HAV	HBsAg	Anti-HAV IgM	HBsAg
1–5	1/2*	1/1	0/2	0/1	0/1
6–10	2/10	4/4	2/10	0/5	0/5
11–15	0/24	3/3	5/24	0/13	0/13
16–20	0/25	5/5	4/45	0	0/12
21–25	0/23	11/11	6/64	0	1/10
26–30	0/20	7/7	10/48	0/3	0/8
31–35	0/12	4/4	4/36	0/1	0/4
36–40	0/8	3/3	1/19	0/2	0/4
41–45	0/4	3/3	3/9	0	0
46–50	0/3	2/2	0/8	0/1	0/2
51+	0/5	1/1	1/14	0	0/3
Total	3/136	44/44	36/279	0/26	1/62

* Number positive/number tested.

Three cases of hepatitis in children between $1\frac{1}{2}$ and 8 years of age demonstrated the presence of anti-HAV-IgM, but none of the 26 controls tested demonstrated its presence. Forty-four cases of hepatitis were examined for the presence of anti-HAV. They were all positive for antibodies to HAV.

The total IgM and IgG levels (mg/dl) were estimated in a group of 19 acute, convalescent and control serum samples. There was no significant difference in the mean values of total IgM and IgG levels, between acute, convalescent and control groups ($P > 0{\cdot}05$).

DISCUSSION

Our investigations indicate that about 1200 individuals in Kolhapur City became ill with frank symptoms of hepatitis between mid February and the end of March 1981. The increase in the number of admissions to hospitals and the house-to-house survey clearly suggested an epidemic situation prevailing in the city. This increase began during the third week of February with a peak in the second week of March. Therefore the early cases of the epidemic had an onset some time between the second and third week of February. Assuming the incubation period of water-borne epidemic hepatitis to be around 40 days (Viswanathan & Sidhu, 1957), the events that led to the present epidemic must have occurred during the second week of January 1981.

The epidemiological studies clearly support the assumption of gross contamination of raw water at source with the epidemic. The indirect evidence was derived from the significant and conspicuous differences in the attack rates in the five wards. The attack rate in E ward was 66·08 per 10000 compared with 6·6 to 17·52 per 10000 in the other wards. The source of water supply to E ward was different. The hepatitis cases recorded in E ward were distributed along the entire length of the water supply line. Thus the sharp concentration of cases in E ward and a more or less continuous distribution of cases suggest a common source of infection.

Although the bacteriological examination of water was not routinely carried

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out, some of the household water samples collected between 12 and 14 January suggested contamination with *Escherichia coli*. Around the same period complaints were received from consumers that white particulate matter was detected in their domestic water supply. These observations suggest that contamination occurred around the second week of January. Moreover, our investigations revealed that a substantial quantity of raw sewage was flowing into the Panchaganga river about 50 m from the jack well. The contamination at this point had obviously continued over a period, as evidenced by the results of bacteriological examination of raw water at the site of the jack well, which indicated a heavy *E. coli* contamination during the second week of March.

Contamination of raw water at source, and an inadequate water monitoring and surveillance system contributed to the onset of the hepatitis epidemic at Kolhapur. Under the circumstances one cannot underestimate the impact of these events on the community. Less than 26 years ago an explosive epidemic of hepatitis had broken out in Delhi, India and had caused about 29300 cases of frank icterus within a period of 6 weeks (Viswanathan, 1957). This and the other epidemics of hepatitis reported in India (Sreenivasan *et al.* 1978) emphasize that contamination of public water supply systems contributes significantly to the health problems of urban communities.

The sex and age distributions have shown a relative excess of males affected. However, there was no significant difference in the mean ages in each sex. As evidenced from hospital admission records, the mean ages during the epidemic and endemic periods did not show significant variation (mean age, $27 \pm 13{\cdot}6$ years). The greater number of cases recorded in young adults presumably reflects their relatively high susceptibility. The reduced number of cases in the elderly population probably indicates greater resistance. A lower number of cases in children suggests that this may be due to a decreasing clinical attack rate below the age of 10 years.

The clinical symptoms observed in this study were similar to those reported earlier (Viswanathan & Sidhu, 1957; Sreenivasan *et al.* 1978). However, the clinical manifestations were less severe and most of the patients did not develop any residual effects. The overall mortality was low.

Khuroo *et al.* (1981) reported a high incidence of fulminant hepatitis in pregnant women during an epidemic of NANB type. In the present study, out of the 12 pregnant females affected only one died due to fulminant hepatitis. Since HBsAg was detected in acute-phase sera of this patient, either direct HBV infection or NANB infection in an HBV carrier might be responsible for the fatal outcome. The remaining 11 pregnant women recovered from NANB hepatitis without any complications.

The serological studies showed that out of 279 cases of hepatitis, 12·9% could be accounted for by hepatitis B virus (HBV) infection, as evidenced by the detection of HBsAg in blood. Therefore, HBV infection was not primarily responsible for this epidemic. The higher rate of HBsAg recorded during the epidemic is consistent with our earlier observations (Sreenivasan *et al.* 1978). This could either mean that there is an increase in HBV infection during the epidemic period or it implies that most of the sporadic cases admitted to the hospitals are due to HBV infection. The latter explanation seems more probable since 77·8%

of HBsAg-positive patients recorded in this study were hospitalized, and the HBsAg incidence among hospitalized sporadic cases in the nearby area (Pune) is around 22·5% (unpublished data of the National Institute of Virology). The sera from patients were screened for the detection of IgM class antibody to HAV (Deinhardt & Gust, 1982). However, 133 out of 136 patients did not have IgM antibody to HAV, but showed past infection with HAV as evidenced by the demonstration of antibodies to HAV in all the 44 patients. This suggests that HAV was not responsible for the epidemic. Thus the hepatitis cases encountered during the epidemic at Kolhapur were not associated with HBV or HAV infection. In the earlier studies it was demonstrated that the aetiological agent responsible for the water-borne epidemic hepatitis in India was neither HAV nor HBV (Wong *et al.* 1980; Pavri *et al.* 1982). In the absence of direct serological tests available for diagnosis of this disease these agents have been classified under a new entity termed epidemic NANB hepatitis with faeco-oral mode of transmission (Dienstag, Stevens & Szmuness, 1981). Our serological investigations suggest that the epidemic of hepatitis reported from Kolhapur is also an epidemic NANB hepatitis.

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